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SUBCLINICAL RENAL DYSFUNCTION AS AN ULTRASOUND PREDICTOR OF COGNITIVE IMPAIRMENT

Abstract

Subclinical renal dysfunction is increasingly recognized as a systemic condition associated not only with cardiovascular morbidity but also with cognitive decline. Structural and hemodynamic changes in the kidneys may precede overt laboratory abnormalities and can be detected using ultrasound and Doppler techniques. Growing evidence suggests a close kidney–brain interaction mediated by shared microvascular pathology. This study reviews the role of renal ultrasound markers as early predictors of cognitive impairment, emphasizing their value in risk stratification before clinical manifestation of chronic kidney disease or dementia.

Keywords: subclinical renal dysfunction; renal ultrasound; Doppler ultrasound; renal resistive index; kidney–brain axis; cognitive impairment; cerebral small vessel disease; vascular cognitive decline; microvascular dysfunction; early diagnosis.

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KOGNITIV BUZILISHLARNING ULTRATOVUSH BASHORATCHISI SIFATIDA SUBCLINIK BUYRAK DISFUNKSIYASI

Abstrakt

Subklinik buyrak disfunksiyasi nafaqat yurak-qon tomir kasalliklari, balki kognitiv pasayish bilan bog'liq tizimli holat sifatida tobora ko'proq tan olinmoqda. Buyrakdagi strukturaviy va gemodinamik o'zgarishlar aniq laboratoriya o'zgarishlaridan oldin bo'lishi mumkin va ultratovush va doppler usullari yordamida aniqlanishi mumkin. O'sib borayotgan dalillar umumiy mikrotomir patologiyasi tufayli buyrak-miya o'rtasidagi yaqin o'zaro ta'sirni ko'rsatmoqda. Ushbu tadqiqot surunkali buyrak kasalligi yoki demensiyaning klinik namoyon bo'lishidan oldin xavf stratifikatsiyasida buyrak ultratovush markerlarining ahamiyatini ta'kidlab, kognitiv buzilishlarning dastlabki bashoratchilari sifatidagi rolini ko'rib chiqadi.

Tayanch iboralar: subklinik buyrak disfunksiyasi; buyrak UTT; Dopplerografiya; buyrak rezistiv indeksi; buyrak-miya o'qi; kognitiv buzilishlar; miya mayda tomirlari kasalligi; qon tomir kognitiv pasayishi; mikrovaskulyar disfunksiya; erta tashxis.

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СУБКЛИНИЧЕСКАЯ ПОЧЕЧНАЯ ДИСФУНКЦИЯ КАК УЛЬТРАЗВУКОВОЙ ПРЕДСКАЗАТЕЛЬ КОГНИТИВНЫХ НАРУШЕНИЙ

Абстракт

Субклиническая почечная дисфункция все чаще признается системным состоянием, связанным не только с сердечно-сосудистыми заболеваниями, но и с когнитивным снижением. Структурные и гемодинамические изменения в почках могут предшествовать явным лабораторным нарушениям и могут быть обнаружены с помощью ультразвуковых и допплеровских методов. Растущие данные указывают на тесное взаимодействие между почками и мозгом, опосредованное общей микрососудистой патологией. В данном исследовании рассматривается роль ультразвуковых маркеров почек как ранних предикторов когнитивных нарушений, подчеркивая их ценность в стратификации риска до клинических проявлений хронической болезни почек или деменции.

Ключевые слова: субклиническая почечная дисфункция; ультразвуковое исследование почек; Допплерография; резистивный индекс почек; ось почек и мозга; когнитивные нарушения; заболевания мелких сосудов головного мозга; сосудистое когнитивное ухудшение; микрососудистая дисфункция; ранняя диагностика.

Introduction

Cognitive impairment represents a major global health burden, particularly in aging populations. While traditionally associated with neurodegenerative and cerebrovascular diseases, cognitive decline is now understood as a multisystem process involving vascular, metabolic, and inflammatory mechanisms. The kidney and brain share similar microvascular architecture and susceptibility to endothelial dysfunction, making renal pathology a potential surrogate marker of cerebral microangiopathy.

Subclinical renal dysfunction refers to early structural or hemodynamic alterations of the kidneys that occur before a significant decline in glomerular filtration rate or elevation of serum creatinine. Ultrasound imaging provides a non-invasive method for detecting these early changes. Identification of renal ultrasound predictors may allow earlier recognition of patients at risk for cognitive impairment.

Materials and Methods

Renal ultrasound assessment includes grayscale imaging and Doppler evaluation of intrarenal and main renal arteries. Morphological parameters such as kidney size, cortical thickness, and parenchymal echogenicity are analyzed. Doppler ultrasound focuses on hemodynamic indices, particularly the renal resistive index (RRI) and pulsatility index (PI), which reflect intrarenal vascular resistance.

Table 1. Renal ultrasound markers associated with cognitive impairment

Ultrasound parameter	Subclinical change	Clinical implication
Cortical thickness	Reduced	Early parenchymal damage
Parenchymal echogenicity	Increased	Chronic microstructural changes

Renal resistive index	>0.70	Microvascular dysfunction
Pulsatility index	Increased	Arterial stiffness

Cognitive status is evaluated using standardized neuropsychological tests assessing memory, executive function, attention, and processing speed. Correlation analysis is performed between ultrasound-derived renal parameters and cognitive performance scores.

Figure 1. Renal ultrasound markers of subclinical dysfunction

Results

Ultrasound examination reveals that individuals with preserved renal function by laboratory criteria may exhibit increased cortical echogenicity and reduced cortical thickness, suggesting early parenchymal involvement. Doppler studies frequently demonstrate elevated RRI and PI values, indicating increased intrarenal vascular resistance.

Statistical analysis shows a significant association between elevated RRI and reduced cognitive scores, particularly in executive function and processing speed domains. These findings persist after adjustment for age, hypertension, and diabetes, supporting an independent relationship between subclinical renal dysfunction and cognitive impairment.

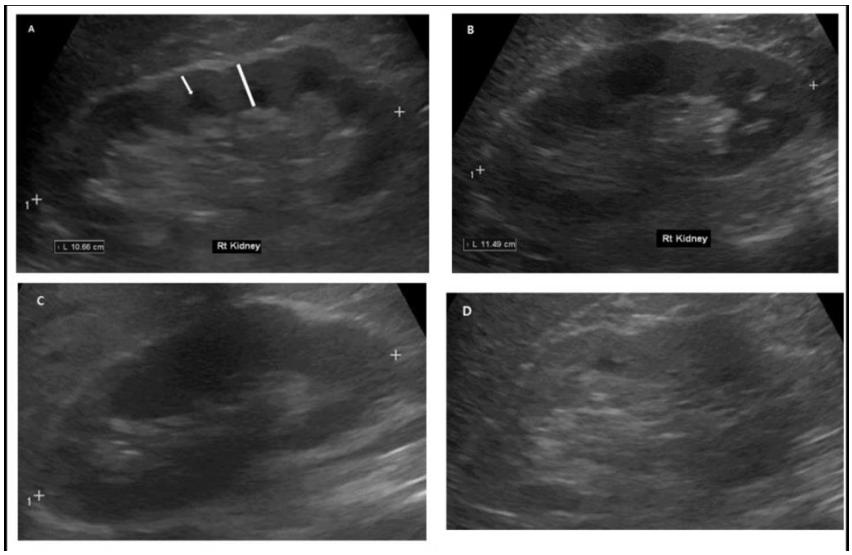
Table 2. Cognitive domains correlated with renal Doppler indices

Cognitive domain	**Correlation with RRI**
Executive function	Strong
Processing speed	Moderate
Memory	Moderate
Attention	Weak–moderate

Discussion

The observed correlation between renal ultrasound markers and cognitive impairment supports the concept of a kidney–brain axis. Increased intrarenal vascular resistance likely reflects systemic microvascular disease affecting both renal and cerebral circulation. Elevated RRI has been linked to arterial stiffness, endothelial dysfunction, and cerebral small vessel disease.

Figure 2. Conceptual kidney–brain interaction



Ultrasound-based renal assessment offers several advantages as a predictive tool: it is widely available, non-invasive, repeatable, and does not involve ionizing radiation. Detection of subclinical renal abnormalities may therefore serve as an early warning sign of impending cognitive decline, enabling preventive strategies and closer neurological monitoring.

Conclusion

Subclinical renal dysfunction detected by ultrasound is significantly associated with cognitive impairment, even in the absence of overt chronic kidney disease. Renal ultrasound and Doppler parameters, particularly the resistive index, may serve as early, accessible predictors of cognitive decline. Incorporating renal ultrasound into multidisciplinary risk assessment models could improve early identification and prevention of cognitive impairment.

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